Beef Carcass Boning Lines—Operations, Equipment, and Layouts

Marketing Research Report No. 941

Agricultural Research Service
UNITED STATES DEPARTMENT OF AGRICULTURE
in cooperation with
Oklahoma Agricultural Experiment Station

Preface

This report is based on research conducted under the general supervision of Tarvin F. Webb, investigations leader, Handling and Facilities Research Branch, Transportation and Facilities Research Division, Agricultural Research Service, in cooperation with the Oklahoma Agricultural Experiment Station.

Robert J. Keller, acting head of the Meat Facilities Group, Plant and Facilities Branch, Standards and Services Division, Animal and Plant Health Inspection Service, USDA, and his staff made suggestions on technical problems related to the arrangement of equipment and work areas for boning lines.

The authors gratefully acknowledge the cooperation of the operators of boning lines who made their facilities available for study and provided supplemental data such as average weights of carcasses boned, crew sizes, hours worked during peak-volume and low-volume months, wage rates, and equipment installation and maintenance costs. The authors also acknowledge the help given by the equipment suppliers who provided cost estimates for a number of items.

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Summary

Plants that specialize in boning cows can realize a 12-percent reduction in the total labor, equipment, and facility costs by employing a conveyor table system rather than a separate table system. This reduction amounts to approximately 45 cents a carcass, or about $15,102 annually, when boning 33,500 carcasses.

Most of these boning lines are operated at 100-percent capacity for about 30 weeks a year and at about 65-percent capacity for the remaining 22 weeks. For the size plant covered in this report, 100-percent capacity is 150 carcasses daily and 65-percent capacity is 100 carcasses daily. A plant running at capacity 30 weeks per year and at 65-percent capacity the remaining 22 weeks would bone an annual volume of 33,500 carcasses. However, if the conveyor boning system were operated at capacity (150 carcasses per day) throughout the year, it could handle 39,000 carcasses instead of the 33,500 carcasses. With an annual increase in volume to 39,000 carcasses, the labor cost per carcass would not change, but the better utilization of equipment and facilities could reduce the boning cost per carcass by 3 cents, or from $3.26 to $3.23 per head, for the most efficient system.

With an annual volume of 33,500 carcasses, labor costs represent about 93 percent of the total labor, equipment, and facility costs for the typical table system, and about 92 percent for the more efficient conveyor table system. The labor required to remove bones from meat cuts comprises about 75 percent of the total labor costs with the table system, and about 83 percent with the conveyor system. Annual boning labor costs are about $2,900 lower with the conveyor system than with the table system.

Equipment costs for the conveyor system are more than double those for the table system. The 32-foot-long conveyor boning table and the two byproduct conveyors account for all of the increase in equipment costs.

The floorspace required for the conveyor system is about 46 percent less than for the table system, which represents a saving in facility costs of about 8 cents per carcass boned, or about $2,685 annually.

Background

Cows make up the major part of all cattle used for boning in the Southwest and Midwest. While most plants also bone bull carcasses, this volume is insignificant when compared with the volume of cow carcasses boned. For the most part, cattle used for boning are culls from range and dairy herds and, if graded, practically all would fall within the U.S. Department of Agriculture grades of cutter and canner. Approximately 90 percent of the boned meat from each carcass is used for ground beef and for processed meat (canned meat and sausages). The remaining 10 percent—tenderloins, rib rolls, and sirloin strips—is normally used in the preparation of less expensive steaks.

The average carcass weight found during this study was about 450 pounds. Although a few boning lines limit their work to carcasses within a narrow weight range, the boning lines observed during this study used carcasses that

ranged from about 200 to 700 pounds in weight. For example, at one boning line, 16 of 175 carcasses to be boned in one day weighed under 350 pounds, and 19 weighed over 650 pounds.

This study included plants located in the Southwest and Midwest. Detailed industrial engineering studies were made at nine selected boning lines, and 11 additional lines were visited to obtain background information. Fourteen of the boning lines studied were a part of individual slaughtering plant operations. Six were in separate boning houses that usually obtained carcasses for boning from several slaughterers.

About half of the 20 plants visited were in facilities designed for boning beef cattle. The remainder were in remodeled beef coolers, refrigerated warehouses, or buildings that were constructed originally for other industries. Often, one or more of the following conditions existed: Holding rails for storing an adequate supply of carcasses at the breaking areas were poorly arranged, work areas were crowded and poorly arranged, and aisles were too narrow and too congested.

Of the 20 boning lines studied and visited, six lines boned less than 100 carcasses daily, 10 boned between 100 and 175 carcasses daily, and four boned between 175 and 325 carcasses daily. Normally, the number of carcasses boned daily fluctuated at least 10 percent. Since more carcasses are available during the late spring, summer, and fall than in winter, about 70 percent of the annual volume of beef to be boned is boned during a 30-week period. As a result, many lines must increase their number of weekly working hours and their working crew size during the peak-volume season.

Beef carcasses are transported to the boning area on trolleys hung on an overhead rail. Slaughtering plants normally quarter the carcass sides in the boning room before they divide them into cuts suitable for boning.

Most plants use one of two boning systems in which there are numerous variations in equipment arrangement. The older system (the table system) has a number of separate boning tables on which the bone-in cuts are placed manually for workers (boners) to remove the bones and trim the meat. Metal containers are located nearby to accumulate the boned cuts.

A newer system has a belt or slat conveyor that extends down the center of a long table. Boning stations are located on both sides of the conveyor. The conveyor is used to transport bone-in cuts to the boners and to transport the boned meat to the packing area, thereby eliminating the manual transport of heavy bones in cuts and container transport of boned cuts. Use of the conveyor system also eliminates the need for an aisle between the rows of boning tables, which reduces the required floorspace by about 46 percent.

For several years a third boning system has been used successfully by boning plants in Australia and Ireland. With this system, carcass sides are boned while suspended from an overhead rail. Although an article on the Australian procedure was published in 1966 in a national meat magazine,[1] no published information was available in January 1968 to indicate that any boning line operator in the United States had conducted a feasibility study of this system of boning beef carcasses. In 1968, the Agricultural Research Service meat research office at Stillwater, Okla., in cooperation with a national meat packer, evaluated this on-the-rail boning system. The results of this research were published in 1971 in ARS 52–63, "Boning Carcass Beef On the Rail: A Feasibility Study."

Another publication related to beef boning line operations was published in May 1968. This report, ARS 52–29, "Procedures for Handling Byproducts Removed During Beef Boning," evaluated four different transport distances and volumes and three types of equipment, plus two combinations of these types, used to transport bones, fat, and inedible trimmings from the boning stations to the renderer's truck outside.

The objectives of this research on beef carcass boning lines were to compare the relative efficiency and operating costs for the table and conveyor systems, and to develop guidelines and efficient layouts for use by the meat industry in planning the optimum boning line for its needs.

To provide boning line operators with more usable information, the research results in this report are presented in two parts. In the first

[1] ANONYMOUS. Boning Beef on Power Rails Grows in Importance in Australia. The Natl. Provisioner 154(16): 24–26. 1966.

part, the labor requirements and labor costs are compared for boning carcass sides for daily volumes of 100 and 150 carcasses, respectively. An average carcass weight of 450 pounds is assumed in computing all data. The second part of the report illustrates how these data can be used in conjunction with equipment costs to compare boning line operations for an assumed annual volume of 33,500 carcasses (150 carcasses daily for 30 weeks and 100 carcasses daily for 22 weeks). Also included are guidelines and layouts for boning lines.

Boning Line Operations—Labor Requirements and Costs

Boning line operations generally follow the same sequence. Carcass sides or quarters are transported on an overhead rail to the boning room, where weight tags and neck pins are removed and excess fat and defects are trimmed. Sides are ribbed, quarters are broken (separated) into cuts for boning, and bone-in cuts are transported to the boning stations. At the boning station, bones, excess fat, and inedible trimmings are removed from the meat cuts and the boned meat is transported to the packing area. At the packing area, the meat is packed in boxes according to specifications and is weighed and stacked on transport equipment. Unit loads are moved to the freezer or to the shipping department after each lot has been inspected. The bones, excess fat, and inedible trimmings are transported to the renderer's truck, which is parked outside, or to an offal cooler.

The boning room work to be covered in this report has been limited to the four operations that normally influence the selection of a boning system. The first operation, breaking carcasses, covers separating carcass sides into meat cuts and transporting bone-in cuts to boning stations. The second operation, boning meat, covers removing bones and excess fat from meat cuts and trimming the boned meat. The third operation covers the transporting of the boned meat to the packing area. The last operation, transporting byproducts, covers transporting bones, inedible trimmings, and excess fat to the renderer's truck or to an offal cooler.

Breaking Carcasses

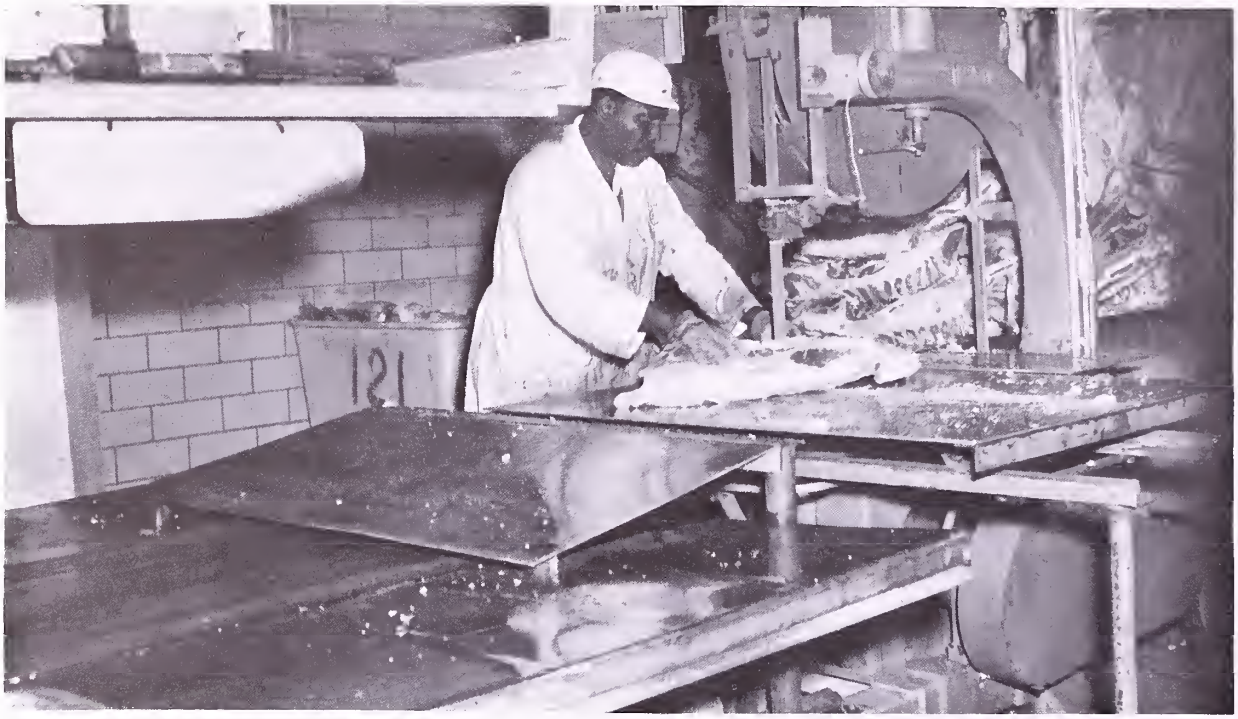
When carcass sides are needed, a breaking crew worker walks to a supply of sides on the overhead rail and checks several to see whether all of their tags and neck pegs have been removed; if not, he removes them. Then, using a handsaw, he saws through the backbone between the 12th and 13th ribs on each side. He then uses a knife to cut partly through the intercostal meat until only a 4- or 5-inch piece of flank meat holds the forequarter to the hindquarter. The worker usually pushes two of the ribbed sides on the rail to the breaking area each trip.

The forequarter is separated from the hindquarter by severing the 4- to 5-inch piece of flank meat. The forequarter is placed on the breaking table. Here, normally the foreshank, shoulder clod, and blade bone are removed before the forequarter is sawed into three pieces (long plate, rib, and chuck).

After the forequarter has been separated from the hindquarter, the hindquarter is pushed on the rail to a quarter dropper which lowers the hindquarter from a height of about 11 feet above the floor to a height of about 7½ feet above the floor. While the hindquarter is still hanging on the 7½-foot high rail, the breaking crew cuts off the flank, saws off the 13th rib end, removes the kidney and excess fat, and pulls the tenderloin. Next, the hindquarter is removed from the trolley hook and placed on the breaking table, and the empty trolley is placed in a container. The hindquarter is moved to the bandsaw and sawed into a loin and round.

After the forequarter and hindquarter are cut into pieces by the saw, all the bone-in cuts are transported, either on the conveyor or manually, to the boning stations (figs. 1 and 2).

The labor required to separate carcass sides, break quarters, and deliver bone-in cuts can vary significantly, depending upon the arrangement of the overhead rails, the breaking area, and the type of boning system used.



PN–2532

FIGURE 1.—Carcass-breaking worker grasps a long plate to transfer it to the belt conveyor for transport to the boning stations.

Table system breaking operation

A typical overhead rail arrangement for the table boning system is a single 11-foot-high rail that holds a supply of beef sides, loops to within 3 feet of the breaking table, and then continues on to a quarter dropper.

Generally, a supply of carcass sides that requires about a half-hour's work is moved manually from the holding cooler into the boning room at one time. Thus, the breaking workers (at a typical line) walk about 40 feet, round trip, to obtain sides needed at the breaking table. Since the 11-foot-high overhead rail used with this system does not extend over the breaking table, two workers generally are required to separate the forequarter from the hindquarter. One worker holds the forequarter in position while the second worker steadies the hindquarter and cuts through the flank meat holding the two quarters together. After the forequarter and hindquarter are separated, the first worker places the forequarter on the breaking table while the other worker pushes the hindquarter onto the quarter dropper, which lowers it to a 7½-foot-height. When it is needed for the next step in the breaking process, it is pushed along the rail to the bandsaw, a distance of about 10 feet.

The preparation of the hindquarter for sawing by removing the flank and other pieces is done at the accumulating area on the 7½-foot-high rail or at the bandsaw. After a worker removes the hindquarter from the trolley hook, he places it on the breaking table and places the empty trolley in a container. After the forequarter and hindquarter are sawed into bone-in cuts, one or more workers manually deliver the cuts to the boning tables. The distance these workers travel each trip is determined by the boning-line size; the larger the line size, the greater the average distance that meat is transported. At boning lines that handle between 100 and 200 carcasses daily, the round-trip distance averaged about 45 feet per trip. Eleven trips were required to transport one complete carcass.

Conveyor system breaking operation

Several of the lines using the conveyor boning system had efficient work area arrangements for producing bone-in cuts from carcass sides. Instead of having one holding rail for carcass sides, they had two or more connected by automatic switches. The switches acted automatically to permit the meat to flow in the desired direction without the worker's having to reset them each time sides were moved toward the breaking table and hindquarters were moved back to the quarter dropper. As a result, the required round-trip distance walked by the worker in pushing the needed sides along the rail to the breaking table was only 20 feet, in comparison with 40 feet required with the table system.

With this system, only one man normally is required to separate a forequarter from a hindquarter because the rail extends over the breaking table and a rail stop prevents the trolley from rolling. In addition, hindquarters can be transported by gravity from the quarter dropper to the breaking table if the rail is sloped about one-half inch per foot between the quarter dropper and the breaking table.

Comparison of labor requirements and labor costs for breaking carcasses by two systems for daily volumes of 100 and 150 carcasses

Table 1 shows the labor requirements and labor costs for separating carcass sides into meat cuts and transporting bone-in meat to the boning station, by boning system, crew size, and elapsed time. When 100 or 150 carcasses are prepared daily, fewer workers are required with the conveyor system than with the table system, primarily because of the labor-saving features of the conveyor. Based on a wage rate of $3.50 per hour, which was the average rate for these workers in the Southwest and Midwest at the time of this study, the use of the conveyor method reduces labor costs by about 28 cents per carcass when boning both 100 and 150 carcasses daily.

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FIGURE 2.—Carcass-breaking worker ready to pick up a chuck manually at a saw to transport it to a boning station.

TABLE 1.—*Labor requirements and labor costs for separating carcass sides into meat cuts and transporting bone-in meat to boning station, by daily volume, boning system, crew size, and elapsed time*[1]

Daily volume and boning system	Crew size	Elapsed time	Labor requirements			Labor costs[3]
			Productive	Unproductive[2]	Total	
	Number	*Hours*	*Man-hours*	*Man-hours*	*Man-hours*	*Dollars*
100 carcasses:						
Table	3	7.36	21.91	0.17	22.08	77.28
Conveyor	2	7.07	14.14	0	14.14	49.49
150 carcasses:						
Table	[4]5	7.94	32.87	.84	33.71	117.99
Conveyor	[4]3	7.69	21.21	.02	21.23	74.30

[1] Tables 7 and 8 in the appendix contain a description of the work performed and the labor required per occurrence.

[2] Waiting time caused by an irregular flow of work between crew members.

[3] Based on a wage rate of $3.50 per hour, the average rate for these workers in the Southwest and Midwest at the time of this study.

[4] One worker performs other assigned plant work between cycles of work on the breaking crew.

Appendix table 7 contains a description of the labor required per occurrence for performing various boning line work elements, by boning system and work element. Appendix table 8 shows the labor required for performing boning line operations, by operation, boning system, and work element, for boning 100 and 150 carcasses daily.

Boning Meat

The boning operation includes: (1) Positioning the meat cut at the work places; (2) removing bones; (3) trimming off meat scraps and discarding the bones; (4) trimming off inedible portions, fat, and meat to shape the boneless cuts; (5) cutting some larger cuts into two or more pieces; and (6) disposing of the finished cuts and trimmings.

Boning knife used for cleaning bones

At most of the boning houses studied, the boners trimmed meat scraps from the bones with a hand knife; however, a few houses had one or two workers that used a mechanical, bone-trimming knife to clean the loin, rib, and chuck bones. Most boning house operators acknowledged the superiority of the mechanical knife over the hand knife in removing meat scraps. They indicated an objection to the use of the mechanical knife, however, primarily because the boning workers would not be as careful in removing bones from meat if they knew that the trimmed bones would be cleaned later with a mechanical knife. Since these meat scraps usually are the least valuable meat, most boning house operators doubted whether the cost of the small increase in the overall yield that is possible by trimming the bones with a mechanical knife would be warranted in comparison with the cost of the lower yield of more valuable meat cuts and the omission of the trimming operation.

Trimming and packing boned meat

The amount of trimming required on the boned meat cuts varied from practically none at some lines to almost every piece at others. All plants packed the rib-eye rolls and tenderloins separately, and some packed separately several specific cuts that were well trimmed. The reason given for the variations in packing was that the plant packed according to customer specifications.

Comparison of labor requirements and labor costs for boning meat by two methods for daily volume of 100 and 150 carcasses

At the lines studied, workers boned either selected meat cuts or all types of meat cuts. At lines where boners boned only selected meat cuts, the work loads for the entire crew of boners were unevenly distributed because some boners had a large backlog of bone-in meat throughout the day while other boners waited for cuts to bone. At lines where all the boners boned all types of meat cuts, the entire crew of boners was kept supplied with bone-in cuts, and thus, there was no backlog of bone-in meat.

Table 2 shows the labor requirements and labor costs to bone meat cuts and to cut and trim boned meat with a hand knife, by the daily volume, method, crew size, and elapsed time. The unproductive time (2.50 and 3.91 man-hours) shown for the selected meat cuts was due primarily to the lack of balance in the work load for the boning crews. The data given are based on cutting and trimming the following meat cuts: Foreshank, long plate, rib, square chuck (without the shoulder clod and blade bone), loin (without the tenderloin and flank), and round. Based on a wage rate of $3.50 per hour, which was the average rate for meat boners in the Southwest and Midwest at the time of this study, the labor cost per carcass was about 9 cents less for both 100 and 150 carcasses daily when the all cuts method was employed rather than the selected cuts method.

Transporting Boned Meat

With the conveyor boning system, the boners normally transport the boned meat cuts and edible trimmings to the packing area by placing them on a conveyor (fig. 3). No labor is required to transport the boned meat by the conveyor system. With the table boning system, the boners place the boned meat in adjacent containers for manual transport to the packing area. Most houses using containers, employ four-wheel sausage-type meat trucks with capacities from about 300 to 800 pounds. When they are boning only specific meat cuts, a few boning lines place the boned meat in boxes along the front of the work stations (fig. 4), which reduces the time required by the packing workers, since they do not have to pack these boxes. The packed boxes are transported manually to the packing area for weighing.

Table 3 shows the labor requirements and labor costs for transporting boned meat to the packing area, by daily volume, boning system,

TABLE 2.—*Labor requirements and labor costs to bone meat cuts and to cut and trim boned meat, by daily volume, method, crew size, and elapsed time*[1]

Daily volume and method	Crew size	Elapsed time	Labor requirements			Labor costs[3]
			Productive	Unproductive[2]	Total	
	Number	*Hours*	*Man-hours*	*Man-hours*	*Man-hours*	*Dollars*
100 carcasses:						
Selected cuts[4]	10	7.40	71.50	2.50	74.00	259.00
All cuts[5]	10	7.16	71.50	.10	71.60	250.60
150 carcasses:						
Selected cuts	14	7.94	107.25	3.91	111.16	389.06
All cuts	14	7.67	107.25	.13	107.38	375.83

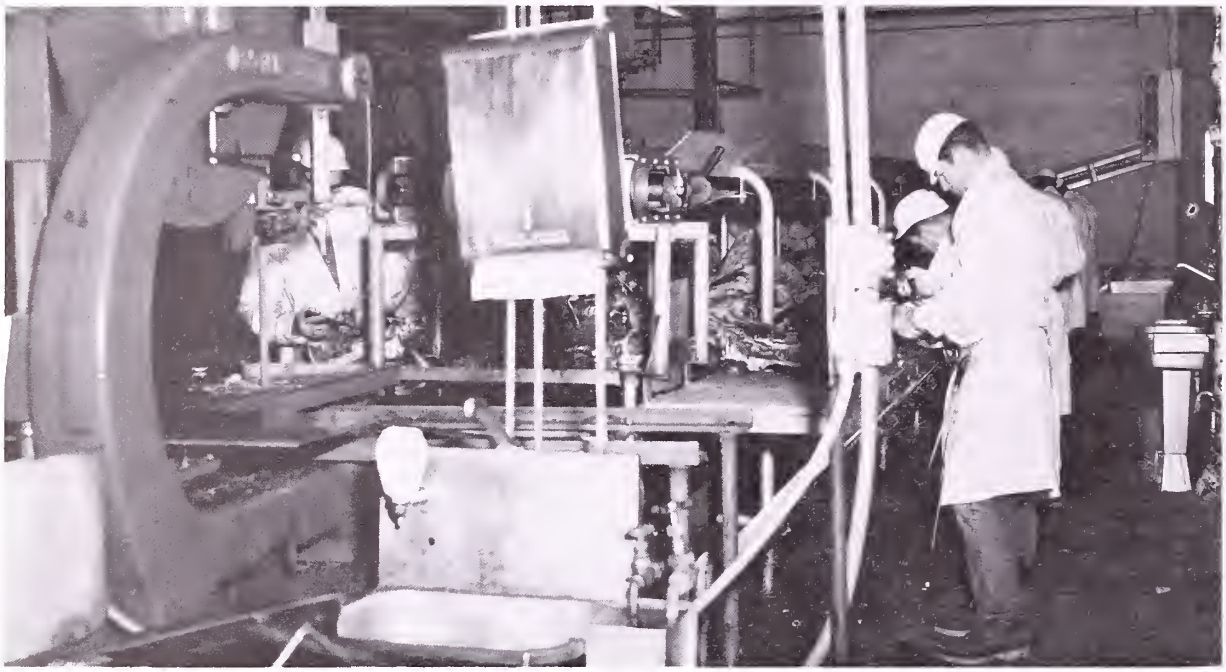
[1] Tables 7 and 8 in the appendix contain a description of the work performed and the labor required per occurrence.

[2] Waiting time caused by an irregular flow of work between crew members.

[3] Based on a wage rate of $3.50 per hour, the average rate for meat boners in the Southwest and Midwest at the time of this study.

[4] Workers bone only one type of meat cut.

[5] Workers bone all cuts of meat.



PN-2534

FIGURE 3.—A conveyor boning table.

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FIGURE 4.—Two boners at work tables with boxes along the front of the work stations to hold boned meat.

TABLE 3.—*Labor requirements and labor costs for transporting boned meat to packing area by daily volume, boning system, and trips required, for a 100- and 150-carcass daily volume*[1]

Daily volume and boning system	Trips required[2]	Labor	
		Productive time	Costs[3]
	Number	*Man-hours*	*Dollars*
100 carcasses:			
Table system	68	0.60	1.80
Conveyor	—	0	0
150 carcasses:			
Table system	101	.89	2.67
Conveyor	—	0	0

[1] Tables 7 and 8 in the appendix contain a description of the work performed and the labor required per occurrence.

[2] The number of trips required was based on a 450-pound carcass, a 75-percent meat yield, and an average load of 500 pounds.

[3] Based on a wage rate of $3.00 per hour, the average wage rate for meat handlers in the Southwest and Midwest at the time of this study.

and trips required, for a 100- and 150-carcass daily volume. It was assumed that the meat yield from each 450-pound carcass was 337.5 pounds, or 75 percent of the carcass. The load in the meat truck averaged 500 pounds. The required round-trip distance was 72 feet, and the meat handler who transported the meat performed other assigned work when he was not busy on this job. Based on a wage rate of $3.00 per hour, which was the average wage rate for meat handlers in the Southwest and Midwest at the time of this study, the labor cost was about 1.8 cents per carcass.

Transporting Byproducts

The byproducts consist of the bones, excess fat, and inedible trimmings removed from the meat cuts. With the table system, the byproducts are placed in a 55-gallon barrel, which holds from about 125 to 200 pounds, and transported with a two-wheel barrel truck or in a two-wheel, general purpose truck which holds from 400 to 800 pounds of byproducts (fig. 5).

With the conveyor system, the byproduct belt conveyor, located above and parallel to the conveyor boning table, connects with a second byproduct conveyor (fig. 6) which transports the byproducts to the renderer's truck parked outside the boning room (fig. 7). An alternate possibility, not considered in this report, is to have one byproduct conveyor placed above the conveyor boning table which would allow the byproducts to drop into a chute leading to a two-wheel, general purpose truck positioned at one end of the conveyor (fig. 8).

Although a number of combinations of methods to transport byproducts are in use, this study covered only the use of barrels with the table boning system, and two byproduct conveyors with the conveyor system. Table 4 gives the labor requirements and labor costs to transport byproducts to the offal cooler in barrels, when boning 100- to 150-carcasses daily. As can be seen in the table, no labor is required with the conveyor system.

For this study, the byproduct yield from a 450-pound carcass was assumed to be 25 percent (112.5 pounds) of the carcass. The following conditions were also assumed: An average byproduct load of 155 pounds for a barrel, a round-trip distance of 160 feet for both 100 and 150 carcasses boned daily, and transport of the

TABLE 4.—*Labor requirements and labor costs for transporting bones, fat, and inedible trimmings to the offal cooler, by daily volume, boning system, and trips required, when boning 100 and 150 carcasses daily*[1]

Daily volume and boning system	Trips required[2]	Labor requirements	Labor costs[3]
	Number	*Man-hours*	*Dollars*
100 carcasses:			
Table system	73	2.32	6.96
Conveyor	0	0	0
150 carcasses:			
Table system	109	3.47	10.41
Conveyor	0	0	0

[1] Appendix tables 7 and 8 contain a description of the work performed and the man-hour requirements per occurrence.

[2] The number of trips is based on a 450-pound carcass, a 25-percent bone, fat, and inedible yield, and an average load of 155 pounds.

[3] Based on an hourly wage rate of $3.00 per hour, the average wage rate for meat handlers in the Southwest and Midwest at the time of this study.

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FIGURE 5.—Empty two-wheel, general purpose trucks used for holding and transporting byproducts.

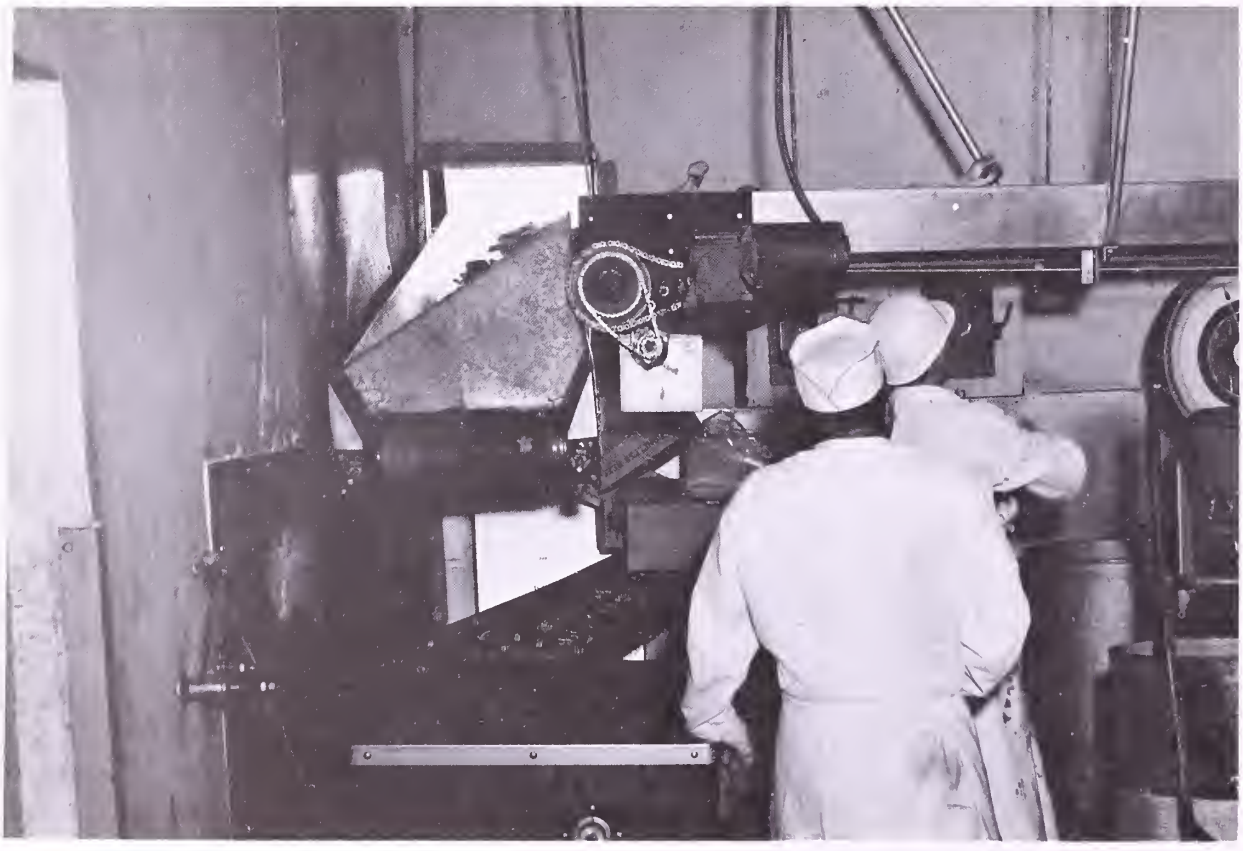

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FIGURE 6.—The second byproduct conveyor transporting the byproducts to the renderer's truck parked outside.

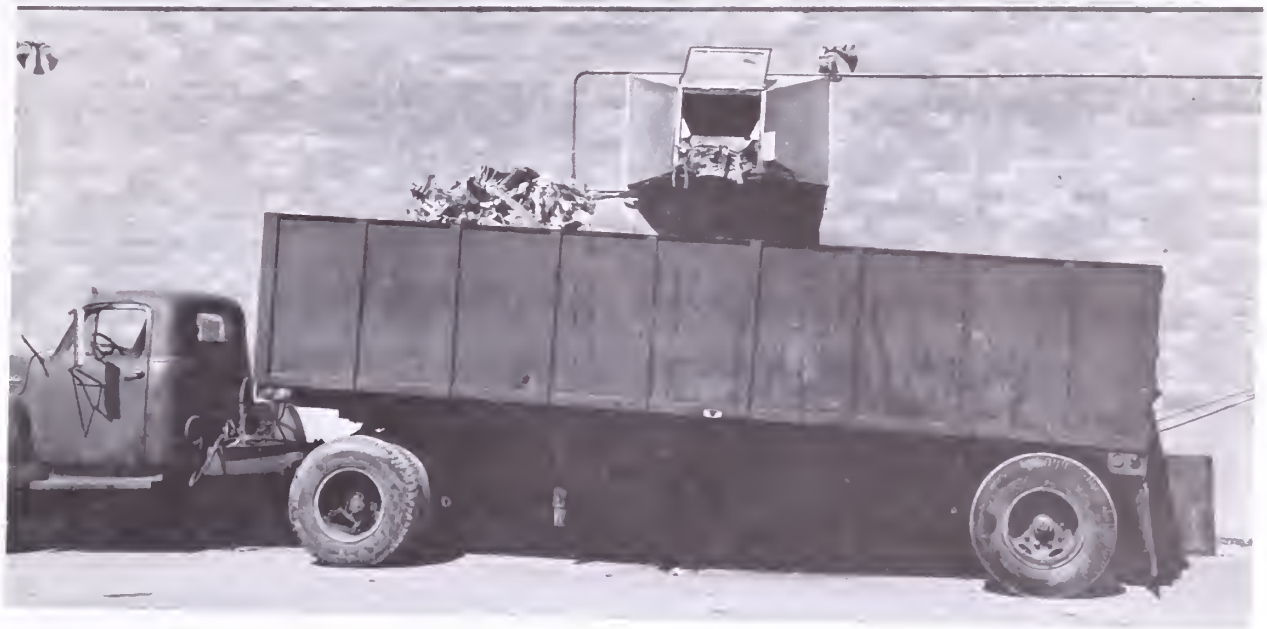

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FIGURE 7.—The byproducts dropping off the second byproduct conveyor into the renderer's truck.

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FIGURE 8.—The byproduct conveyor located over the conveyor boning table empties byproducts into a chute, which leads to a two-wheel, general purpose truck at one end of the conveyor table.

byproducts by a meat handler who was assigned other plant work when he was not needed on this job. Based on an hourly wage rate of $3.00 per hour, the average wage rate for meat handlers in the Southwest and Midwest at the time of this study, the labor cost for transporting byproducts for both daily volumes was slightly less than 7 cents a carcass.

Comparison of Two Boning Systems

A beef carcass boning line selected to illustrate the comparison of labor requirements and labor and equipment costs for the two boning systems[2] had an annual volume of 33,500 carcasses and handled sides only. With the table system, the workers are required to hand-carry bone-in meat cuts from the bandsaw to the boning table and to push trucks of boned meat or byproducts to the work areas. With the conveyor system, the conveyor boning table and the two byproduct conveyors automatically transport products from the bandsaw to the boners, to the packing area, and to the renderer's truck during the boning operations.

A typical boning line layout is included for the table system (fig. 9), and an efficient layout is presented for the conveyor system (fig. 10). These layouts illustrate overall space requirements and arrangements of equipment, aisles, and work areas. Layout guidelines which were developed during this research are discussed. The labor and the equipment requirements and the labor costs used throughout the report are based on the layouts. The layouts are designed to handle a capacity of 150 carcasses daily which would be 39,000 annually; however, the seasonal nature of the supply, as explained earlier in this report, is the basis for assuming an annual volume boned of 33,500.

Annual Labor Requirements and Labor and Equipment Costs

Since the four boning operations—breaking carcasses, boning meat, transporting boned meat, and transporting the byproducts—covered in this report have been discussed in detail, this section is limited to a comparison between the two systems as to the annual labor requirements and labor and equipment costs for performing the four operations (table 5), when the annual volume is 33,500 carcasses. Appendix table 9 lists the annual ownership cost and operating costs for the equipment used with each system.

For the four operations listed in table 5, beef carcasses can be boned at a rate of about 1.01 carcasses per man-hour with the table system, and 1.17 carcasses per man-hour with the conveyor system. Most of the reduction in labor requirements for the conveyor system results because with the conveyor, no manual labor is needed to transport bone-in and boned meat.

The total labor and equipment costs for the four operations is about $3.55 per carcass with the table system and about $3.17 per carcass with the conveyor system. Labor costs comprise about 98 percent of the labor and equipment costs per carcass with the table method and about 95 percent of the total cost per carcass with the conveyor system.

Layouts

In planning a layout for a boning line, five major factors should be considered: (1) The number and kind of carcasses to be boned hourly; (2) the flow pattern of meat and meat byproducts; (3) the floorspace required; (4) the type, size, number, and arrangement of equipment required; and (5) the possible future changes in volume or in type of meat product.

The approximate number of carcasses to be boned hourly during the peak-volume period should be determined at the outset, since crew size, needed equipment, and room dimensions are based primarily on this figure. The hourly rate should be based on an 8-hour work day. Since the cattle boning operations require a great deal of physical effort, most workers would experience a significant drop in productivity from fatigue if they were required to work steadily for more than 8 hours.

The flow that carcasses, boned meat, and by-

[2] The seasonal change for the annual volume is assumed to be 150 carcasses daily for 30 weeks a year and 100 carcasses daily for the remaining 22 weeks.

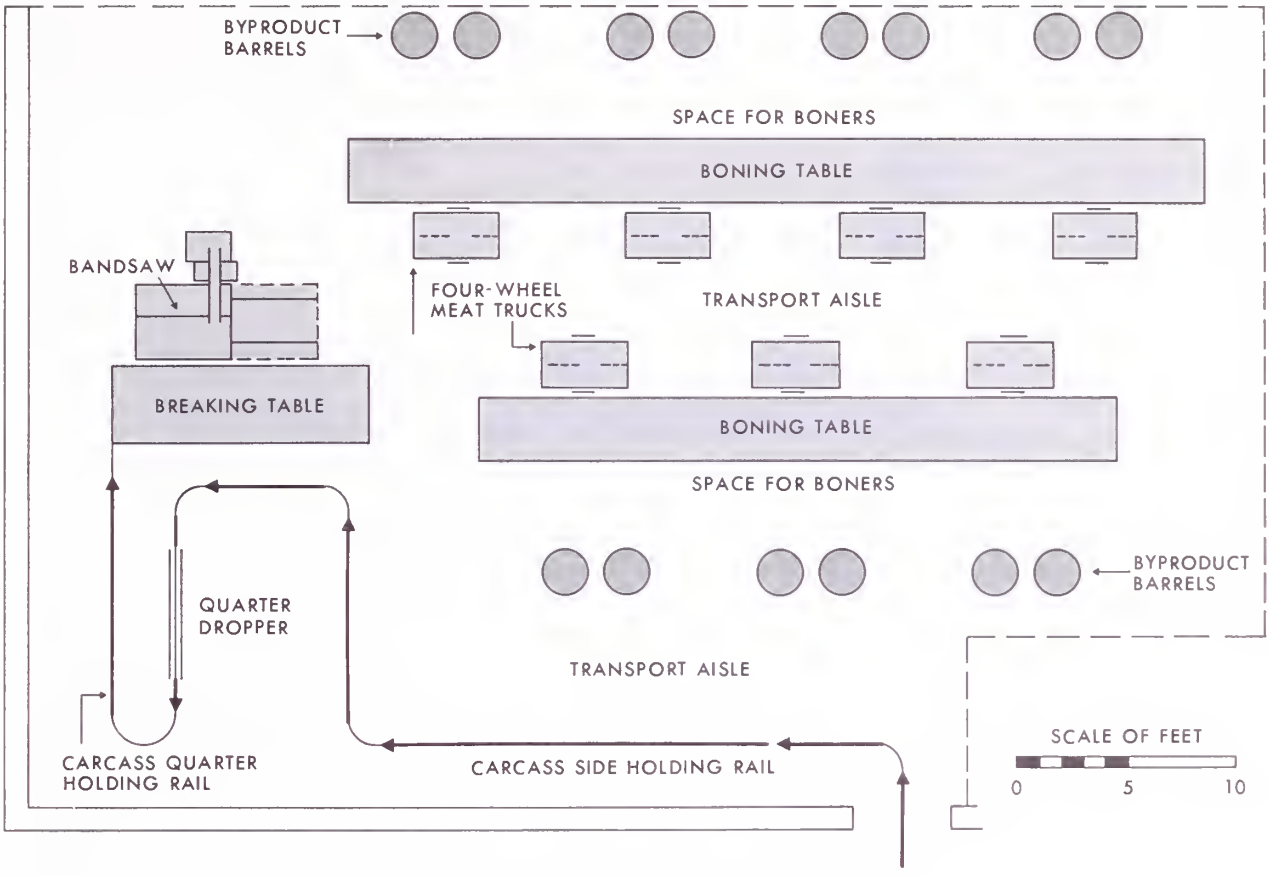

FIGURE 9. —A typical table boning system layout.

products follow, from the time the carcasses enter the boning room until the boned meat is packed in boxes and the byproducts leave the boning area, is a very important factor to be considered in laying out an efficient boning line. The flow pattern of all products should be as direct as possible and planned to minimize product handling and transport between work stations and to eliminate congestion.

The amount of floorspace provided should be based on the size of the equipment to be used, and the amount of floorspace needed for workers operating the equipment. Adequate floorspace between and around equipment is very important for maintenance and cleanup.

The type and size of equipment required should be determined by the volume of carcasses handled and the cost associated with its operation. Equipment arrangement should permit not only the efficient performance of each operation but also a smooth flow of products between operations.

Boning room floorspace should be adequate so that future flexibility of operations is possible. For example, at a future date it might be desirable to add a meat grinder to the room equipment to coarse grind meat trimmings before packing them. The extra floorspace should also allow for a moderate future increase in the hourly boning rate, since several additional boned meat trimming stations often can be set up without a significant loss in line efficiency.

To assure the production and distribution of wholesome meat products, both Federal and State inspection authorities have rigid requirements for construction of beef boning lines. Operators who plan to add new lines or remodel existing ones should submit their plans to proper authorities for approval before beginning construction.

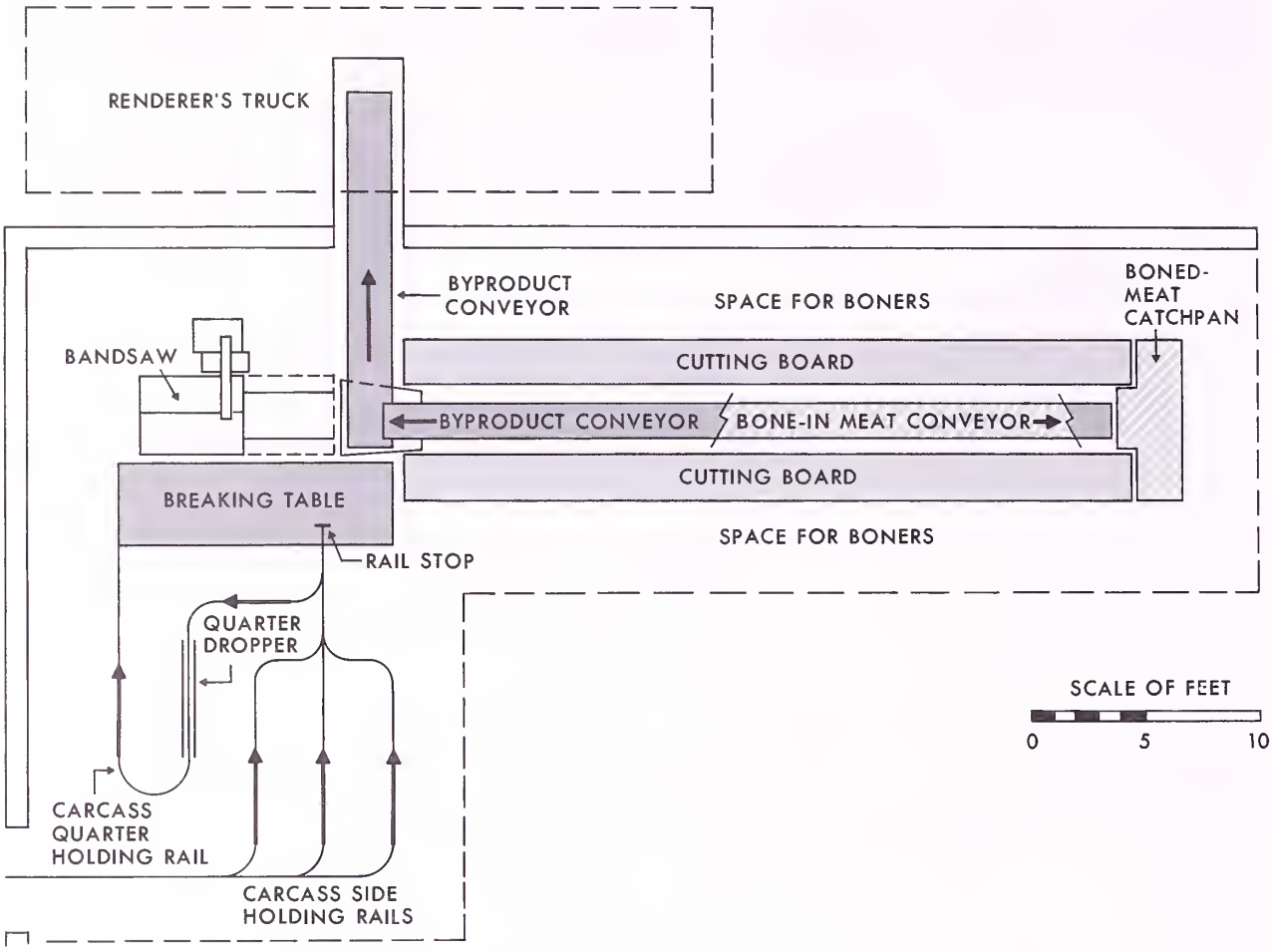

FIGURE 10.—An efficient layout for a conveyor boning system.

A discussion of floorspace required, equipment size, equipment arrangement for a typical boning table system layout, and a typical conveyor boning system layout follows.

Layout for a Table Boning System

A typical layout of a table system for boning about 33,500 carcasses annually is shown in figure 9. To determine the type, size, and amount of equipment needed for this annual volume, a peak boning rate of about 19 carcasses hourly, for a total of 150 carcasses daily, was assumed. A total of 2,034 square feet of floorspace is required for equipment, work areas, and aisles. Space for packing boned meat is not included, since packing generally is not influenced by the type of boning system employed.

The separation of carcass sides into meat cuts requires about 648 square feet of floorspace. The aisles needed to transport bone-in cuts to work stations are included in the boning section of this report, since they are shared with two other operations. The 11-foot-high by 54-foot-long rail can hold about 30 sides. The 7½-foot-high by 18-foot-long rail can hold about 15 hindquarters. A stainless-steel-top breaking table, which is 3½ feet wide by 12 feet long, is provided for the one part-time and four full-time workers engaged in this operation. A 5-horsepower traveling table bandsaw, an electric powered quarter dropper, and 300 rail trolleys are the major items of equipment required for this area.

The area for boning meat cuts requires about 490 square feet of floorspace. Two workers are stationed at each of seven tables which are ar-

TABLE 5.—*Labor requirements, labor costs, and equipment costs for the two boning systems, by operation, when the annual volume is 33,500 carcasses*

Operation	Table system				Conveyor system			
	Labor requirements	Costs			Labor requirements	Costs		
		Labor	Equipment	Total		Labor	Equipment	Total
	Man-hours	*Dollars*	*Dollars*	*Dollars*	*Man-hours*	*Dollars*	*Dollars*	*Dollars*
Rib sides, break quarters, and transport meat cuts	7,485.30	26,198.55	1,816.85	28,015.40	4,739.90	16,589.65	3,739.24	20,328.89
Bone, cut, and trim meats	24,814.00	86,849.00	527.70	87,376.70	23,983.00	83,940.50	397.37	84,337.87
Transport boned meat to packing	199.50	598.50	431.85	1,030.35	—	—	356.82	356.82
Transport bones, fat, and inedible trim to renderer's truck or offal cooler	775.70	2,327.10	28.51	2,355.61	—	—	1,337.53	1,337.53
Total	33,274.50	115,973.15	2,804.91	118,778.06	28,722.90	100,530.15	5,830.96	106,361.11

ranged in two rows—three on one side of an aisle and four on the other side. Each table is 3 by 10 feet with a 4-foot-wide standing and working area for the boners stationed on the outside of the boning tables.

The transport aisles and the equipment maneuvering and parking areas share the remaining 896 square feet of floorspace for this boning system. The two rows of boning tables are 9 feet apart. About 5 feet of this space (2½ feet along each side) is needed to park the four-wheel meat trucks. The remaining 4 feet is used by workers as an aisle for transporting bone-in meat cuts and boned meat trucks. To the rear of the boners on the outside of the two rows of tables, a space 2 feet wide is provided for the byproduct barrels. The equipment used in this area includes nine four-wheel meat trucks, two two-wheel barrel trucks (appendix table 9), and 14 byproduct barrels. The cost of barrels is not included in table 9 because the renderer normally supplies them at no charge.

Layout for a Conveyor Boning System

Figure 10 shows an efficient layout for a conveyor system for boning about 33,500 carcasses annually. The total floorspace required for equipment, work areas, and aisles is 1,095 square feet.

The separation of carcass sides into meat cuts requires about 495 square feet of the total floorspace. The floorspace occupied by the table conveyor in transporting bone-in cuts is included in the boning section of this report. The three 11-foot-high by 9-foot-long carcass side holding rails can hold approximately 30 sides of beef. Up to 12 hindquarters can be accumulated on the 16-foot-long rail that slopes from about 8¼-feet-high at the "off" end of the quarter dropper to about 7½-feet-high at the bandsaw. In addition to the 80 feet of overhead rail in this section of the boning system, this layout requires a rail trolley stop, four rail switches, a friction-type quarter dropper, 300 rail trolleys, a 3½-foot by 12-foot stainless steel top quarter breaking table, and a 5-horsepower bandsaw (appendix table 9). Figure 11 illustrates the use of a rail stop to hold a rail trolley while the forequarter is being separated from the hindquarter.

About 600 square feet of the total floorspace is provided for boning meat and removing the byproducts. Most of this space is occupied by the conveyor boning table. The type recommended for a facility that bones 33,500 carcasses annually is 7 feet wide and 32 feet long. Four feet of its width is used for cutting boards, each 2 feet wide, that extend the length of the table on each of its sides. A stainless steel belt conveyor, about 32 inches wide, runs the length of the table between the two cutting boards. This conveyor is used to transport the bone-in meat from the bandsaw to the boners and the boned meat to the catch pan. With a 14-man boning crew (seven men on each side of the conveyor) each worker's space at the cutting board is 4½ linear feet. The stainless steel board meat catch pan is 2 feet wide, 7 feet long, 1 foot deep, and the same height as the conveyor tables.

A belt conveyor—rather than a slat conveyor—is recommended, because meat trimmings can be removed more easily from the end of a belt conveyor. In addition, a belt conveyor normally can be cleaned in less time at the end of the day. The installed cost of a stainless steel belt conveyor is about $3,000 less than that of a slat conveyor. However, a slat conveyor has several advantages over a stainless steel belt conveyor: It can transport heavier loads; it is less likely to get out of alinement; and, with proper maintenance, it should last substantially longer.

The byproduct conveyor that is parallel with the belt conveyor and about 2½ feet above it (identified hereafter as the first byproduct conveyor) has a 1½-foot-wide, neoprene-type belt of the same length as the stainless steel belt conveyor. This byproduct conveyor transports the byproducts to another byproduct conveyor (identified hereafter as the second byproduct conveyor). The second byproduct conveyor has the same type belt and is 2 feet wide. This conveyor is 16 feet long and extends from the "off" end of the first byproducts conveyor to the renderer's truck parked outside. An electric powered air curtain door is located at the wall opening for the byproduct conveyor to prevent the loss of refrigeration from the room and the entrance of dust and insects.

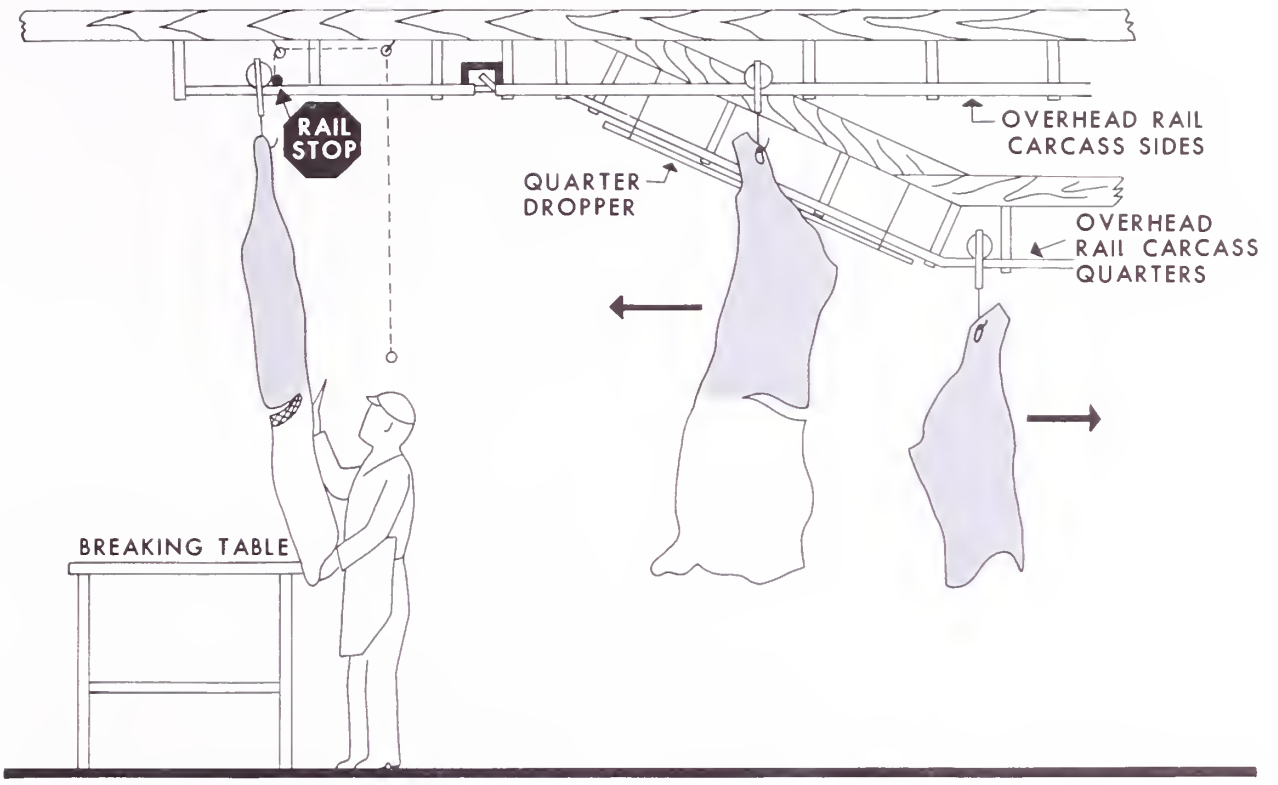

FIGURE 11.—A rail stop holds the carcass trolley while the worker separates the forequarter from the hindquarter.

Annual Costs and Possible Benefits of the Two Systems

The total annual cost of the systems, assuming an annual volume of 33,500 carcasses with each, is $124,595.30 for the table system and $109,492.81 for the conveyor system (table 6). The conveyor system costs $15,102.49 less per year to operate, a difference of about 12 percent. This is a reduction in the total annual cost of about 45 cents per carcass boned.

Annual costs, as used in this report, consist of labor, equipment, and facility costs. Labor cost is $115,973.15, or about 93 percent of the total annual cost for the table system; and $100,530.15, or 92 percent of the total for the conveyor system. The conveyor system cost $15,443.00 less for labor on an annual basis. This is a reduction of about 13 percent.

The equipment cost is $2,804.91 for the table system and $5,830.96 for the conveyor system. The equipment cost was slightly more than 2 percent for the table system and nearly 6 percent for the conveyor system. On an annual basis, the conveyor system cost slightly more than twice as much for equipment as the table system. The significantly higher equipment cost for the conveyor system is due to the three conveyors used with this system.

Facility cost is based on the area required to perform the boning operations. Estimates based on 1970 cost data indicated that construction costs would range from about $20.00 to $30.00 per square foot for space refrigerated to a temperature of 50° F. Since construction costs can vary significantly, depending on the type of building and its location, a construction cost of $25.00 per square foot was assumed for this report. Building ownership costs are based on 30 years' depreciation, computed by the straight-line method with no residual value, interest on investment based on 6 percent using the formula $E = \frac{R(N+1)}{2N}$ (where E = actual interest rate, R = stated interest rate, and N = depreciable life in years), and combined insur-

TABLE 6.—*Comparison of costs for two boning systems when the annual volume is 33,500 carcasses*

Cost classification	Table system		Conveyor system	
	Cost per carcass boned	Annual cost	Cost per carcass boned	Annual cost
	Dollars	*Dollars*	*Dollars*	*Dollars*
Labor	3.46	115,973.15	3.00	100,530.15
Equipment	.08	2,804.91	.17	5,830.96
Facility	.17	5,817.24	.09	3,131.70
Total	3.71	124,595.30	3.26	109,492.81

ance and taxes computed at 4 percent of initial cost. The only operating cost included was a 1-percent allowance for maintenance of the facility. The computed figure results in an annual cost of about $2.86 per square foot of floorspace.

The typical layout for a table boning system requires about 2,034 square feet of floorspace, whereas the efficient layout recommended for a conveyor boning system requires 1,095 square feet. The space required for the conveyor system is 939 square feet less than for the table system—a saving of 46 percent in space required. The total annual facility cost for the amount of floorspace required for the typical table boning system is $5,817.24, and for the conveyor boning system, $3,131.70. This is a saving of $2,685.54 annually when the conveyor system is used rather than the table system.

If enough beef carcasses were available for the boning operation to run at capacity (150 carcasses daily or 39,000 carcasses annually) for 52 weeks per year, the per-carcass cost of boning would be reduced another 3 cents. This reduction would be caused by better utilization of the equipment and the facility, which would lower the unit costs. Labor requirements and costs would remain the same.

Appendix

The data presented in tables 7 and 8 are based on average labor requirements of several different boning lines and should be used only as guidelines in evaluating a specific operation. Many factors that were considered to be beyond the scope of this study were not evaluated; for example, the temperature of the carcasses, the amount of trimming of the meat cut required to meet specifications, and the amount of cleaning that the bones should receive before they are discarded. In the body of the report, no calculations are given for time lost by workers who were idle because they lacked a job assignment or for time lost by workers while they walked from one operation in the boning room to another area to perform another operation.

The labor costs are based on the amount of productive labor required for an operation plus the amount of idle time inherent in the method. A rate of $3.50 per hour is assumed for carcass breakers and boners and a rate of $3.00 per hour for other semi-skilled workers. These rates include the basic wage plus fringe benefits such as social security, workmen's compensation, and hospitalization.

Overhead costs such as refrigeration, heating, management salaries, and purchasing and sales are not included. Labor, equipment, and facility costs directly related to the boning of carcass beef and the transporting of bones and fat out of the boning room are the only costs covered in this study.

Equipment cost data presented in table 9 are based on 1971 average prices (f.o.b. factory) plus a transportation allowance for shipping 500 miles, and an estimated cost for the ma-

terials and the labor needed for installation. Equipment costs are divided into ownership and operating costs. Ownership costs are fixed and include: (1) Depreciation, computed by the straight-line method with no residual value and based on an expected life of 12 years for each equipment item as outlined in U.S. Treasury Department, Internal Revenue Service Publication No. 456 (9–62) ; (2) interest on investment based on 6 percent using the previously given formula; and (3) insurance and taxes, based on a combined figure of 4 percent of the initial investment. Operating costs are variable and include electricity at 2 cents per kilowatt hour and maintenance based on estimates by operators, equipment suppliers, and the authors. The cost for cleanup is not included.

Table—*Transport carcass sides:* Walk to two sides, check for and remove tags and neck pegs missed, and transport two sides on rail to breaking table, average distance round trip 40 feet	0.0058	0.0007	0.0065
Conveyor—*Transport carcass sides:* Walk to two sides, check for and remove tags and neck pegs missed, and transport two sides on rail to breaking table, average distance round trip 20 feet	.0047	.0005	.0052
Table or conveyor—*Rib carcass side:* Saw through backbone between 12th and 13th ribs and cut intercostal meat between these ribs	.0057	.0008	.0065
Table—*Separate forequarter from hindquarter:* Worker holds forequarter while a second worker steadies hindquarter and cuts through connecting meat. Worker places forequarter on breaking table and second worker pushes hindquarter on rail to quarter dropper	.0085	.0013	.0098
Conveyor—*Separate forequarter from hindquarter:* Push forequarter to table, cut through connecting meat and allow forequarter to drop onto table, release rail stop, and push hindquarter on rail to quarter dropper	.0044	.0008	.0052
Table or conveyor—*Prepare forequarter for sawing:* Remove foreshank, shoulder clod, and blade bone	.0221	.0033	.0254
Table or conveyor—*Saw forequarter:* Slide forequarter to bandsaw, saw into long plate, rib, and square chuck	.0066	.0010	.0076
Table—*Transport hindquarter:* Walk to hindquarter, and transport on rail to breaking table, average distance round trip 20 feet	.0025	.0003	.0028
Table or conveyor—*Prepare hindquarter for sawing:* Remove flank, hanging tenderloin, fat, kidney, and tenderloin, saw off 13th rib end	.0113	.0017	.0130
Table or conveyor—*Drop hindquarter:* Remove hindquarter from trolley hook and drop on table, and place trolley in container	.0038	.0006	.0044
Table or conveyor—*Saw hindquarter:* Slide hindquarter to bandsaw, saw into loin and round	.0053	.0007	.0060
Table—*Transport bone-in cuts:* Pick up cut, manually transport cut to boning station, and return to breaking area, average distance round trip 45 feet	.0050	.0006	.0056
Table or conveyor—*Bone foreshank:* Position foreshank at work place, remove bones, trim meat scraps off bones, and dispose of bones, fat, and meat	.0213	.0032	.0245
Table or conveyor—*Bone long plate:* Position long plate at work place, remove bones, trim meat scraps off bones, and dispose of bones, fat, and meat	.0513	.0077	.0590

TABLE 7.—*Labor requirements per occurrence for performing boning line operations, by boning system and work elements*—Continued

Boning system and work element	Labor requirements		
	Base time	Fatigue and personal allowance	Productive time
	Man-hours	*Man-hours*	*Man-hours*
Table or conveyor—*Bone rib:* Position rib at work place, remove bones, trim meat scraps off bones, pull rib roll, and dispose of bones, fat, and meat	.0362	.0054	.0416
Table or conveyor—*Bone square chuck:* Position chuck at work place, remove bones, shape meat, trim meat scraps off bones, and dispose of bones, fat, and meat	.0727	.0109	.0836
Table or conveyor—*Bone loin:* Position loin at work place, remove bones, shape meat, trim meat scraps off bones, and dispose of bones, fat, and meat	.0672	.0100	.0772
Table or conveyor—*Bone round:* Position round at work place, remove bones, shape meat, trim meat scraps off bones, and dispose of bones, fat, and meat	.0410	.0062	.0472
Table or conveyor—*Trim tenderloin:* Position tenderloin at work place, trim to remove excess fat and to shape, and dispose of trimmings and meat	.0087	.0013	.0100
Table or conveyor—*Trim flank:* Position flank at work place, trim off excess fat, and dispose of trimmings and meat	.0125	.0019	.0144
Table—*Transport boneless meat:* Push loaded 4-wheel meat truck to packing area and push empty truck to boning area, average distance round trip 72 feet	.0078	.0010	.0088
Table—*Transport bones, fat, and inedible trimmings:* Engage 2-wheel barrel truck to full barrel, transport load to offal cooler, open doors to boning room and offal cooler on way, release full barrel, engage empty barrel and return to boning area, close doors on way, release empty barrel, average distance round tri feet	.0283	.0035	.0318

TABLE 8.—*Labor requirements for performing boning line operations, by operation, boning system, and work element, for boning 100 and 150 carcasses daily*

Operation, boning system, and work element	Labor requirements				
	Productive time per occurrence	100 carcasses daily		150 carcasses daily	
		Occurrences	Time	Occurrences	Time
	Man-hours	*Number*	*Man-hours*	*Number*	*Man-hours*
Breaking carcasses:					
Table system:					
Transport carcass side	0.0065	100	0.65	150	0.98
Rib carcass side	.0065	200	1.30	300	1.95
Separate forequarter from hindquarter	.0098	200	1.96	300	2.94
Prepare forequarter for sawing	.0254	200	5.08	300	7.62
Saw forequarter	.0076	200	1.52	300	2.28
Transport hindquarter	.0028	200	.56	300	.84
Prepare hindquarter for sawing	.0130	200	2.60	300	3.90
Drop hindquarter	.0044	200	.88	300	1.32
Saw hindquarter	.0060	200	1.20	300	1.80
Transport bone-in cut	.0056	1,100	6.16	1,650	9.24
Total	—	—	21.91	—	32.87
Conveyor system:					
Transport carcass side	.0052	100	.52	150	.78
Rib carcass side	.0065	200	1.30	300	1.95
Separate forequarter from hindquarter	.0052	200	1.04	300	1.56
Prepare forequarter for sawing	.0254	200	5.08	300	7.62
Saw forequarter	.0076	200	1.52	300	2.28
Prepare hindquarter for sawing	.0130	200	2.60	300	3.90
Drop hindquarter	.0044	200	.88	300	1.32
Saw hindquarter	.0060	200	1.20	300	1.80
Total	—	—	14.14	—	21.21
Boning meat, both systems:					
Bone foreshank	.0245	200	4.90	300	7.35
Bone long plate	.0590	200	11.80	300	17.70
Bone rib	.0416	200	8.32	300	12.48
Bone square chuck	.0836	200	16.72	300	25.08
Bone loin	.0772	200	15.44	300	23.16
Bone round	.0472	200	9.44	300	14.16
Trim tenderloin	.0100	200	2.00	300	3.00
Trim flank	.0144	200	2.88	300	4.32
Total	—	—	71.50	—	107.25
Transporting boned meat:					
Table system	.0088	68	.60	101	.89
Conveyor system[1]	—	—	—	—	—
Transporting byproducts:					
Table system	.0318	73	2.32	109	3.47
Conveyor system[1]	—	—	—	—	—

[1] No labor required.

TABLE 9.—*Ownership cost and operating costs for equipment used in performing boning line operations*

Equipment	Amount of equipment	Total initial cost	Annual Cost					
			Ownership			Operating		
			Depreciation[1]	Interest[2]	Insurance and taxes[3]	Power[4]	Maintenance[5]	Total
	Number	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
Table system:								
Overhead rail (72 ft.)	—	173.00	14.42	5.62	6.90	—	2.34	29.28
Overhead rail quarter dropper	1	735.00	61.25	23.89	29.40	19.95	18.75	153.24
Overhead rail trolley	300	1,144.00	95.33	37.18	45.76	—	21.12	199.39
Quarter breaking table (3½ by 12 ft.)	1	500.00	41.75	16.25	20.00	—	4.45	82.37
Bandsaw (5 h.p.)	1	2,533.00	211.08	82.32	101.32	57.62	900.23	1,352.57
Boning table (3 by 10 ft.)	7	2,891.00	240.92	93.96	115.64	—	77.18	527.70
Four-wheel meat truck	9	2,345.00	195.42	76.21	93.80	—	66.42	431.85
Two-wheel barrel truck	2	156.00	13.00	5.07	6.24	—	4.20	28.51
Total	—	10,477.00	873.09	340.50	419.06	77.57	1,094.69	2,804.91
Conveyor system:								
Overhead rail (30 ft.)	—	190.00	15.83	6.17	7.60	—	2.62	32.22
Overhead rail trolley stop	1	43.00	3.58	1.40	1.72	—	.53	7.23
Overhead rail switches	4	169.00	14.08	5.49	6.76	—	6.19	32.52
Overhead rail quarter dropper[6]	1	225.00	18.75	7.31	9.00	—	11.05	46.11
Overhead rail trolley	300	1,144.00	95.33	37.18	45.76	—	21.12	199.39
Quarter breaking table (3½ by 12 ft.)	1	500.00	41.67	16.25	20.00	—	4.45	82.37
Bandsaw (5 h.p.)	1	2,533.00	211.08	82.32	101.32	57.62	900.23	1,352.57
Conveyor boning table (7 by 32 ft.)	1	12,852.00	1,071.00	417.69	514.08	70.09	576.25	[7]2,649.11
Conveyor for bones and fat (over boning table) (1½ by 32 ft.)	1	3,700.00	308.33	120.25	148.00	42.83	100.00	719.41
Conveyor for bones and fat (to outside) (2 by 16 ft.)	1	3,028.00	252.33	98.41	121.12	27.26	69.00	568.12
Air curtain door	1	214.00	17.83	6.96	8.56	11.10	5.55	50.00
Boned-meat catch pan (2 by 7 ft.)	1	556.00	46.33	18.07	22.24	—	5.27	91.91
Total	—	25,154.00	2,096.14	817.50	1,006.16	208.90	1,702.26	5,830.96

[1] Based on an expected life of 12 years as outlined in U.S. Treasury Department, Internal Revenue Service Publication No. 456 (9–62) and computed using the straightline method, assuming no residual value.

[2] Computed at 6 percent of the average investment over the depreciable life of the equipment.

[3] Computed at 4 percent of the initial investment.

[4] Computed at 2 cents per kilowatt hour.

[5] Maintenance programs vary, and the amounts shown are based on estimates.

[6] This quarter dropper uses a friction-type brake instead of an electric-powered auger to lower quarters hung on trolley hooks from an 11-foot-high rail to one 7½ feet high.

[7] Since the conveyor boning table is used in three operations, the total annual cost is allocated at 75 percent to breaking quarters, 15 percent to boning meats, and 10 percent to transporting boned meat.

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